

Fluctuations, Coherence and Predictability of Long Range Shallow Water Propagation in the Straits of Florida

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LONG-TERM GOAL

Understanding long range acoustic propagation in shallow water. The coherence and predictability of long-range shallow water propagation deteriorates with higher frequency and longer range of propagation. We seek to understand the randomizing effect of fluctuations in bathymetry, sound speed and the geo-acoustic properties of the bottom. Usually, a propagating sound field is randomized after tens of kilometers of transmission but occasionally, stable and coherent signals are observed at much longer range (Monjo et al, 1997). We seek to explore these islands of coherence in a sea of chaos.

OBJECTIVES

Most shallow water experiments of the past focused on the fundamental problem of low frequency and short-range propagation resulting in a few acoustic modes. Mode theoretical approaches are used to interpret observations. We seek to expand the scope of observations to cover a broad band of frequencies 100 to 3200 Hz. and longer ranges of transmission with hundreds of modes. We hypothesize that wave-guide effects can produce phase-stationary summations of many modes in a way that will greatly enhance coherence under some conditions.

APPROACH

The approach is experimental. An overview of the propagation experiment in the Florida Straits is shown below. A 3-dimentional receiver array consisting of 96 phones and will use an existing fiber-

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optic link to transmit data to a shore station located at the NSWC facility at the entrance to Port Everglades, Ft. Lauderdale, FL.

A powerful autonomous transmitter, the ASREX source, will be moored at each of 6 ranges, tentatively set at 10, 20, 40, 60, 80 and 100 km from the receiving array. The source will then transmit m-sequences at each of 6 center frequencies, 100, 200, 400, 800, 1600, and 3200 Hz. The bandwidth in each case is 25% of the center frequency. The transmissions will continue for 14 days, long enough to resolve diurnal components and tides. Four separate moorings, placed between source and receiver, will measure the temperature vs. depth profile at 12 depths to be used for the estimation of range dependent sound speed profiles.

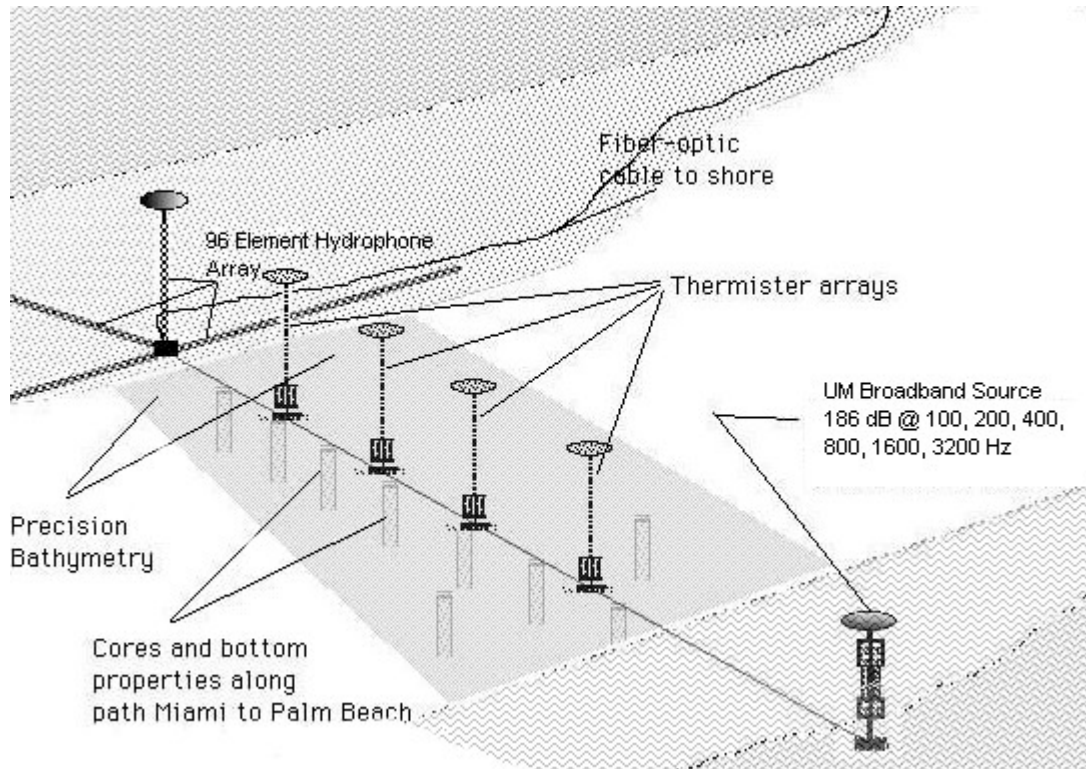


Figure 1 Shallow water acoustic coherence experiment

WORK COMPLETED

Parabolic Equation (PE) modeling of the site of next summer's acoustic experiment was done at all frequencies (100, 200, 400, 800, 1600, 3200 Hz) using Monterey-Miami PE code developed by Dr. Kevin Smith of the Naval Postgraduate School and Dr. Fred Tappert of the University of Miami. Codes were modified to supply documentation required for our Environmental Impact Assessment report which is being prepared by Mr. Bill Baxley of the South Florida Testing Facility (SFTF) (Naval Surface Warfare Center, Carderock Div). Instrumentation has been acquired using DURIP funds to prepare for the upcoming experiments. Orders have been placed for the 1600 and 3200 Hz transducer augmentation and bids are out for the newly-designed hydrophone arrays that will be placed on the SFTF range next summer. Mooring design programs have been acquired and utilized to test and refine designs for the acoustic moorings. Linux-based computers and fiberoptic hardware have been acquired and are being used to test data transfer rates and data acquisition software being developed for the

cable-based hydrophone arrays. Custom circuitry has been developed. Monthly meetings with our South Florida Ocean Measurement Center (SFOMC) partners have been used to coordinate our activities with oceanographic measurements being planned for the same time frame as the acoustic experiments. Common data formats have been discussed and selected.

RESULTS

Modeling estimates indicate that sound pressure levels should be within acceptable limits for sea life and human divers expected to be in the vicinity of the planned experiment. Equipment acquired thus far has performed well and we anticipate no problems communicating with the hydrophone arrays once they are put in place next summer and acquiring data at rates of 20 Mb/s or more.

IMPACT/APPLICATIONS

The development of the SFOMC test range hardware and related acoustic modeling and environmental characterization will be of enormous benefit to a number of Navy-sponsored research programs. A STTR contract should be in place early next year to further develop a "Probe Source" instrument (see also Environmentally Adaptive Broadband Sonar for ASW and MIW --Navy STTR topic N97T003 Phase I report for contract N00014-97-C-0299). This instrument, which utilizes pseudo-random sequence codes and a unique compact transducer design to probe and learn about the surrounding environment, will be tested on the SFOMC range facilities being developed and modeled. In addition, researchers in acoustic inverse methods, should find many uses for acoustic data sets that will be acquired. The combination of precise measurements and survey data to be acquired in FY99 should be useful in testing shallow water acoustic inversion methods.

TRANSITIONS

A small and expendable probe source and a shipboard receiver system have been developed for the direct measurement of the acoustic transmission characteristics of shallow water sound channels. The device is 4 inches in diameter and can be deployed from the signal tube of a submarine. Once launched, the source positions itself in the water column and transmits a broadband signal that is coded for pulse compression. The coding and coherent processing produce a gain of 36 dB so that the transmission may go undetected by a listener without knowledge of the signal properties. The Submarine or AUV can then proceed to measure channel pulse response out to ranges of several tens of kilometers.

The acoustic environment in shallow water is highly variable from site to site and from day to day. Accurate predictions are well beyond the capability of propagation models. The probe source allows for the direct assessment of the acoustic properties of sound channels without dependence on propagation models or the detailed measurement of the ocean environment for model inputs. By combining the measured sound field data with model based inverse methods it becomes possible to predict oceanographic, atmospheric, and geo-acoustic properties of shallow ocean areas. The ability to make direct and inverse observations leads to several applications: 1) sonar performance prediction for tactical decisions, 2) sonar signal processing optimization, 3) enhanced model-based processing and 4) vulnerability estimation.

RELATED PROJECTS

The South Florida Ocean Measurement Center will be host to a number of oceanographic and acoustic measurements in FY99 in addition to our own. This will include Dr. Mark Luther's temperature and conductivity measurements (University of South Florida), Dr. Lynn (Nick) Shay's OSCAR radar measurements of surface currents (University of Miami), Dr. John Van Leer's Cyclosonde profiling measurements, as well as acoustic and other measurements performed by Florida Atlantic University researchers. The aforementioned "Probe Source" work will also benefit from our acoustic hardware developments, modeling and environmental measurements.

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